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Radar wind comparisons on the Ocean Weather Ships (second series)

by

D. N. HARRISON
(Meteorological Office)

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Summary

A repetition of the trials made in 1949 (MRP 508) shows a small but definite improvement in the systematic and random errors of range and in the mean vector difference of wind measurement between two ships. Azimuth and elevation errors are about the same as before.

1. Introduction

Since MRP 508 was written attempts have been made to improve the accuracy of the radar wind observations in the Ocean Weather Ships. Improvement was sought in three directions, (1) in the observational drill, (2) in the standard of maintenance of the equipment, (3) by modification of the equipment. In the case of (1) and (2) it was realized that there were no obvious defects and that progress could only be made by attention to details. In the case of (3) it was found that appreciable improvement could only be expected from major changes which it was impracticable to make; the only feasible modifications were minor ones relating to the range display, and a list of the modifications made is given in the Appendix.

In order to test the success of these attempts, a second series of comparisons was made at sea. The methods of observation and computation were the same as those described in MRP 508. The results are given in Tables I, III and IV, corresponding to Tables I, III and IV of MRP 508. In Table I, where signs are given they represent, as before, the differences obtained by subtracting the readings of the ship named second from those of the ship named first, e.g. Watcher minus Explorer. The approximate elevation angles near the beginning and end of each ascent have been added. Table II gives the state of the sea, and remarks where observations are missing.

2. Radar readings: systematic differences

Considering first the mean differences (Table I, columns 6-10), it will be seen that whereas in 1949 differences of range up to more than 2,000 yards were found, they are now not more than about 500 yards, while the azimuth and elevation differences are about the same as before. There is a tendency for a given pair of ships to show systematic differences of the same sign on successive occasions. The azimuth differences are naturally reflected in differences of wind direction.

3. Radar readings: random differences

The mean deviations (Table I, cols. 11 and 12) are practically the same as before. These, however, as explained in MRP 508, are not a good measure of the scatter which is chiefly responsible for errors in wind measurement, on account of the existence of long-period changes or drift. A better measure is the average change, without regard to sign, between successive observations, of the difference between the two ships' readings. These are shown in cols.

/13-15.

13-15. The value for range has improved from 190 yds. in 1949 to 100 yds. in the present series, while the values for azimuth and elevation are practically unchanged at 0.9° and 0.5° respectively. If the observational errors are proportional to these figures, the contribution of the angular errors to the vector wind error is considerably greater in general than that of the range error, so that the improvement to be expected in wind measurement is small.

4. Vector differences of wind measurement

Table III should be compared with Table III of MRP 508. There has been a small improvement, the mean of 392 values being 6.8 knots (7.4 kt.in 1949), or, giving equal weight to each ascent, 6.9 kt. (7.3 kt.in 1949). The improvement is found at every level except 1,000 ft. and 2,000 ft., where the mean differences are now much greater than before. The reason for the large values at these low levels is not known. In both series the mean vector difference increases from the lower levels to a maximum at about 30,000 - 40,000 ft., and tends to decrease above this height; this decrease may not, however, be genuine, as the data are far from homogeneous, the number of ascents reaching high levels falling off rapidly. There is no obvious explanation of the very large differences which occur in individual measurements, including one of 50 knots.

The frequency distribution is shown in Table IV, and is practically the same as that given in Table IV of MRP 508. 46 per cent of the differences lie in the range 0-4 kt. (i.e. less than 4.5 kt.) and 89 per cent in the range 0-14 kt. (less than 14.5 kt.). In 1949 the percentages were 46 and 90.

There is no connexion between the mean vector difference for an ascent and the state of the sea. Both the highest and the lowest difference occur on an ascent when the sea was slight, while for sea rough and moderate-rough the differences are quite small. There is a tendency for calm or slight sea to be associated with high elevations in the early stages of an ascent, which may cause loss of observations, since the radar aerials are limited to an elevation of about 70°.

The trials were organized and most of the computation for this paper was done by Mr. R.F.M. Hay and the staff of the Marine Branch of the Meteorological Office. A high standard of care and accuracy is shown in the observations by the staff of the ships; there is a remarkable absence of gross errors of reading of the kind which would be revealed in the computation, and the results probably represent the best that the equipment is capable of giving.

References

Harrison, D.N. 1949 Meteorological Research Papers, Air Ministry, London. No. 508.

Table I. Difference of Radar readings

1 Ascent No.	2 Date	3 No. of obs.	4 Range 1000's yds.	5 Approx. elev. min.	5 Approx. elev. end	6 Mean difference Range (yds.) First 5	7 Mean difference Range (yds.) Last 5	8 Mean difference Range (yds.) Mean	9 A 0	10 E 0	11 Mean deviation A 0	12 Mean deviation E 0	13 Mean change between successive obs. R yds.	14 Mean change between successive obs. A 0	15 Mean change between successive obs. E 0
WATCHER - EXPLORER															
2	25. 4.53	31	8-53	41	22	- 50	-910	-460	+1.7	+1.5	1.1	0.5	110	0.4	0.4
20	31. 7.54	44	1-43	34	29	+460	+650	+410	-4.8	-3.1	1.0	0.4	100	0.5	0.3
26	23.10.54	42	4-55	38	19	- 70	-800	-420	-0.3	-2.0	1.9	0.7	150	0.9	0.4
EXPLORER - RECORDER															
7	31.10.53	43	1-28	38	49	-120	+140	+ 30	+3.3	+1.7	3.0	0.7	80	1.2	0.5
10	2. 1.54	40	4-54	27	24	-430	-500	-520	+3.5	+1.5	1.2	0.5	90	1.1	0.5
11	22. 1.54	24	10-38	27	25	-100	-140	- 80	+0.4	+2.1	1.9	0.5	70	0.7	0.3
15	17. 4.54	28	10-48	34	24	- 20	-170	-120	+3.6	-0.7	1.0	0.8	80	0.4	0.5
17	8. 5.54	39	2-45	32	24	+ 70	+100	+110	+7.9	+4.0	2.1	0.9	150	0.8	0.6
23	20. 8.54	28	5-35	62	32	-240	-410	-250	+2.6	+3.8	1.5	0.7	80	0.7	0.6
OBSERVER - WATCHER															
1	5. 4.53	31	3-37	23	24	-340	-390	-165	+0.5	-0.3	1.2	0.4	180	0.5	0.1
12	23. 1.54	36	4-60	33	19	-180	-270	-160	-0.2	-0.8	0.9	0.8	100	0.7	0.4
14	6. 3.54	18	1-10	57	60	-150	-130	-140	+9.1	-2.1	2.0	1.7	70	1.8	1.3
16	17. 4.54	33	2-25	60	53	- 90	-100	- 80	-3.2	+2.4	1.6	1.5	70	1.5	1.0
22	20. 8.54	7 & 14	3-6 & 16-25	41	72	-110	-250	-210	-3.3	+2.8	1.7	2.4	40	1.5	1.4
24	2.10.54	42	1-68	39	17	- 10	+420	+360	-0.1	+3.8	3.3	1.1	130	0.7	0.6
27	13.11.54	36	2-79	30	13	+110	+390	+340	-2.8	+2.7	2.6	1.2	90	0.6	0.5
RECORDER - OBSERVER															
3	21. 6.53	33	6-43	23	27	+120	+560	+350	+1.7	0.0	0.8	0.8	80	0.7	0.3
4	29. 8.53	17	11-28	-	41	-190	- 80	- 75	+0.9	-1.5	1.3	0.6	100	0.9	0.5
21	1. 8.54	34	2-50	24	21	+ 70	-200	-110	+0.7	-3.9	1.6	0.3	90	0.8	0.2
25	23.10.54	33	4-78	26	13	+100	-240	-120	-6.0	+0.3	1.7	0.9	120	0.9	0.4
RECORDER - WATCHER															
5	19. 9.53	47	1-25	70	57	-150	- 90	-110	-4.2	-2.5	1.4	3.1	60	1.1	0.6
6	10.10.53	28	3-83	58	9	-340	-940	-470	-1.6	-1.1	1.4	1.3	210	1.0	0.9
8	13.12.53	26	8-52	40	21	+ 60	- 50	-170	+0.1	-0.2	1.1	1.0	120	1.3	0.5
13	14. 2.54	29	8-64	44	19	+ 50	+ 60	-170	-0.4	0.0	1.3	1.1	210	0.4	0.4
18	28. 5.54	33	2-35	55	33	-190	-130	-350	-1.5	+2.6	2.0	1.0	70	1.5	0.5
19	18. 6.54	39	2-26	31	49	+ 40	+ 30	+ 30	+6.0	-2.0	1.6	1.8	80	0.8	0.5
EXPLORER - OBSERVER															
9	15.12.53	31	4-28	35	41	+ 15	- 20	+ 55	+4.3	-0.6	2.2	0.6	50	1.1	0.5
Mean WEATHER EXPLORER		(10 ascents, equal weight to each)									1.7	0.6	100	0.8	0.5
" WEATHER WATCHER		(16 " " " " ")									1.6	1.3	110	0.9	0.6
" WEATHER OBSERVER		(12 " " " " ")									1.7	1.0	90	1.0	0.6
" WEATHER RECORDER		(16 " " " " ")									1.6	1.0	110	0.9	0.5
Mean of all		(27 " " " " ")									1.6	1.0	100	0.9	0.5

Table II. Notes on ascents

Ascent No.	State of Sea	Remarks
2	mod.	E above 70° at first. 1st obs. min. 12.
20	slight	
26	calm-slight	
7	mod.	
10	slight-mod	
11	mod.	First obs. min. 10
15	slight-mod.	
17	slight-mod.	
23	calm	E above 70° at first. 1st obs. min. 10.
1	rough	
12	mod.	
14	slight	E about 60° throughout. Some obs. lost above 70°.
16	calm	
22	slight	E above 70° and obs. unreliable min. 12-27.
24	slight	
27	slight-mod.	
3	mod.	
4	calm-slight	E above 70° first 18 mins; no obs.
21	mod.	
25	mod.	
5	slight	E 52°-70° throughout. Some obs. lost above 70°.
6	mod.	
8	mod.	No parallax correction before min. 10. Obs. omitted.
13	slight-mod.	
18	slight	
19	mod.	
9	mod-rough	

Table III. Vector Difference of Wind Measurement (knots)

Ascent No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Mean	No. of obsns.
Height 1000's feet																													
60					2		8			22						2												8.5	4
55		2		8	3		8			3			8			12			5	5								6.0	9
50		3	20	2	0		5	20	6	5		8	9			5	2	11	3	12			15		12	11		8.3	18
45	4	7	6	5	3		12	13	1	7	4	7	11			8	16	2	4	2	7		28	36	10	2	23	9.5	23
40	6	1	3	10	4		5	16	2	7	7	8	3		17	8	24	5	3	15	11		17	27	10	7	32	10.3	24
35	1	7	3	3	2	30	2	5	6	7	5	6	6		11	3	31	12	4	10	11		13	18	16	9	23	9.8	25
30	2	21	10	3	21	6	6	50	15	5	16	5	7		4	3	17	9	11	2	22		3	17	10	7	7	11.2	25
26	15	5	4	8	11	9	1	18	6	12	9	3	6		8	4	12	3	4	9	19		3	24	4	7	21	9.0	25
23	6	1	6		6	20	4	5	4	6	8	2	4	4	6	6	11	3	2	5	10		6	18	14	9	9	7.0	25
20	3	2	4		7	3	5	12	1	5	13	6	7	3	11	9	10	2	5	3	12		4	23	9	7	9	7.0	25
18	1	3	3		4	10	3	8	2	3	4	6	2	6	10	7	7	2	3	3	11		4	14	16	9	2	5.7	25
16	3		6		1	15	2	4	3	1	7	2	2	1	8	2	6	4	7	2	4		2	8	24	2	3	5.0	24
13	4		2		0	9	1	1	2	3		1	1	0	4	1	30	3	4	1	15	3		6	9	2	15	5.1	23
10	3		0		2		1	0	2	4		8	1	1	3	3	11	4	1	1	4	7		11	3	5	2	3.5	22
8	3		3		3		1	3	6	3		2	2	1	11	5	4	4	1	3	2	2		9	6	2	7	3.8	22
6	3		3		2		1	3		4		3	1	5		2	8	2	1	3	6	2		5	3	4	8	3.5	20
4	4		2		2			3				6	1	7		3	5	1	1	3	2	5		3	1	1	5	3.1	18
2	2		1		1			6				12	7	6		6	5	3	2	6	6	1		5	8	5	8	5.0	18
1	6		1		1			13				13	10	8		4		4	3	7	8	2		7	8	9	11	6.8	17
Mean	4.1	5.2	4.5	5.6	3.9	12.7	4.1	10.6	4.3	6.1	8.1	5.8	4.9	3.8	8.5	4.9	12.4	4.4	3.6	5.1	9.3	3.1	9.5	14.4	9.6	5.8	11.6	6.9	392

Table IV. Frequency distribution of Vector Differences

Vector diff. (kt.)	No. of cases	Percent-age	Vector diff. (kt.)	No. of cases	Percent-age	Vector diff. (kt.)	No. of cases	Percent-age
0	5	1.3	12	10	2.6	24	3	0.8
1	37	9.4	13	5	1.3			
2	49	12.5	14	2	0.5	27	1	
3	56	14.3	15	7	1.8	28	1	
4	35	8.9	16	5	1.3	30	2	
5	28	7.1	17	4	1.0	31	1	2.0
6	33	8.4	18	3	0.8	32	1	
7	26	6.6	19	1	0.3	36	1	
8	22	5.6	20	3	0.8	50	1	
9	16	4.1	21	3	0.8			
10	11	2.8	22	2	0.5			
11	15	3.8	23	3	0.8	Total	392	100.1

Appendix

Modifications to radar wind sets

Weather Watcher

Delayed synch and signal generator fitted 4.9.53.

Range expansion unit fitted 1.11.53.

On 1st voyage after fitting, R.E.U. was used intermittently; after that no periods of unserviceability.

G.41 trigger: started on 4.6.54; not used 10.11.54 to 15.11.54.

Weather Recorder

D.S.S.G. fitted 9.10.53

R.E.U. fitted 9.10.53.

R.E.U. unserviceable 24.10.53 to 3.11.53 and 15.4.54 to 19.4.54.

G.41 trigger: Not used.

Weather Explorer

D.S.S.G. fitted 19.12.53

R.E.U. fitted 18.1.54

Unserviceability: None.

G.41 trigger: Not used.

Weather Observer

D.S.S.G.)
R.E.U.) fitted January 1954.

Unserviceability: None.

G.41 trigger: Not used.